Mechanical Properties Considerations for Fast Core Propellants

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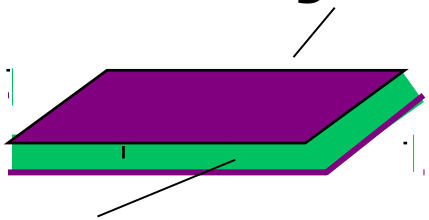
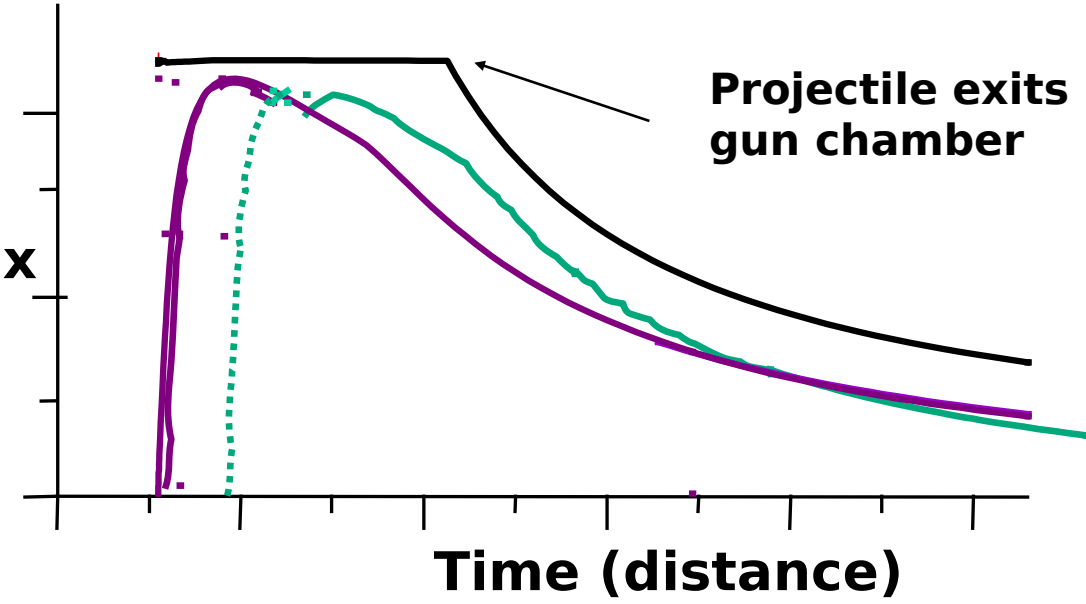
Layered Propellants for Improved Ballistic Perform

Burn Rate Ratio: > 2.5 : 1

Slow Burning Outer Layer



Fast Burning Inner Layer



Chemical progressivity: distinct propellant formulations

- **Avoid plasticizers to prevent migration & recrystallization problems**

Novel colayered geometries

High loading densities > 1.25 g/cc

Fast-Core Enabling Technologies are Revolutionary and Impose Tough Constraints on the Propellant

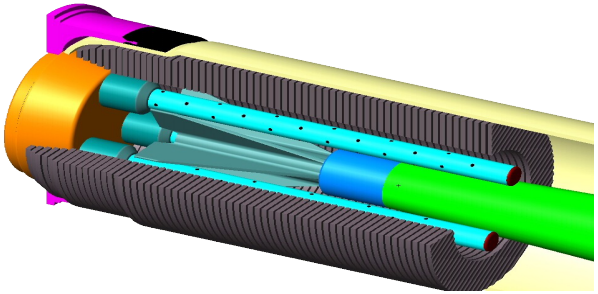
Very High Energy Density

High Energy Propellant

High Loading Density Propellant ~1.3 gm/cc vs ~ 0.95 gm/cc

Vertical Disk Configuration

Important limitations on ignition & flamespread



Schematic

Fast-Core Imposes Tough Constraints on the Propellant

Electrothermal Chemical Ignition

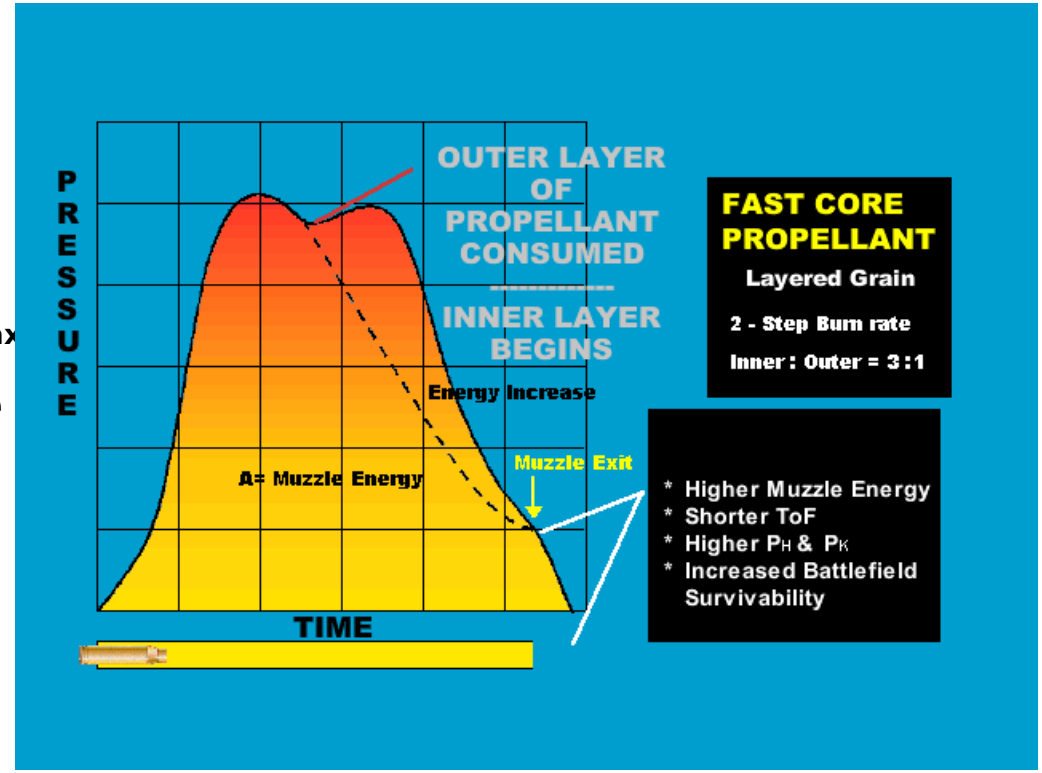
Needed as an Enabler for High Loading Density Charges

Plasma could cause unpredictable behavior with thin layers/coatings

Breech Pressure,

(as opposed to Gun P_{max}

May Limit Performance

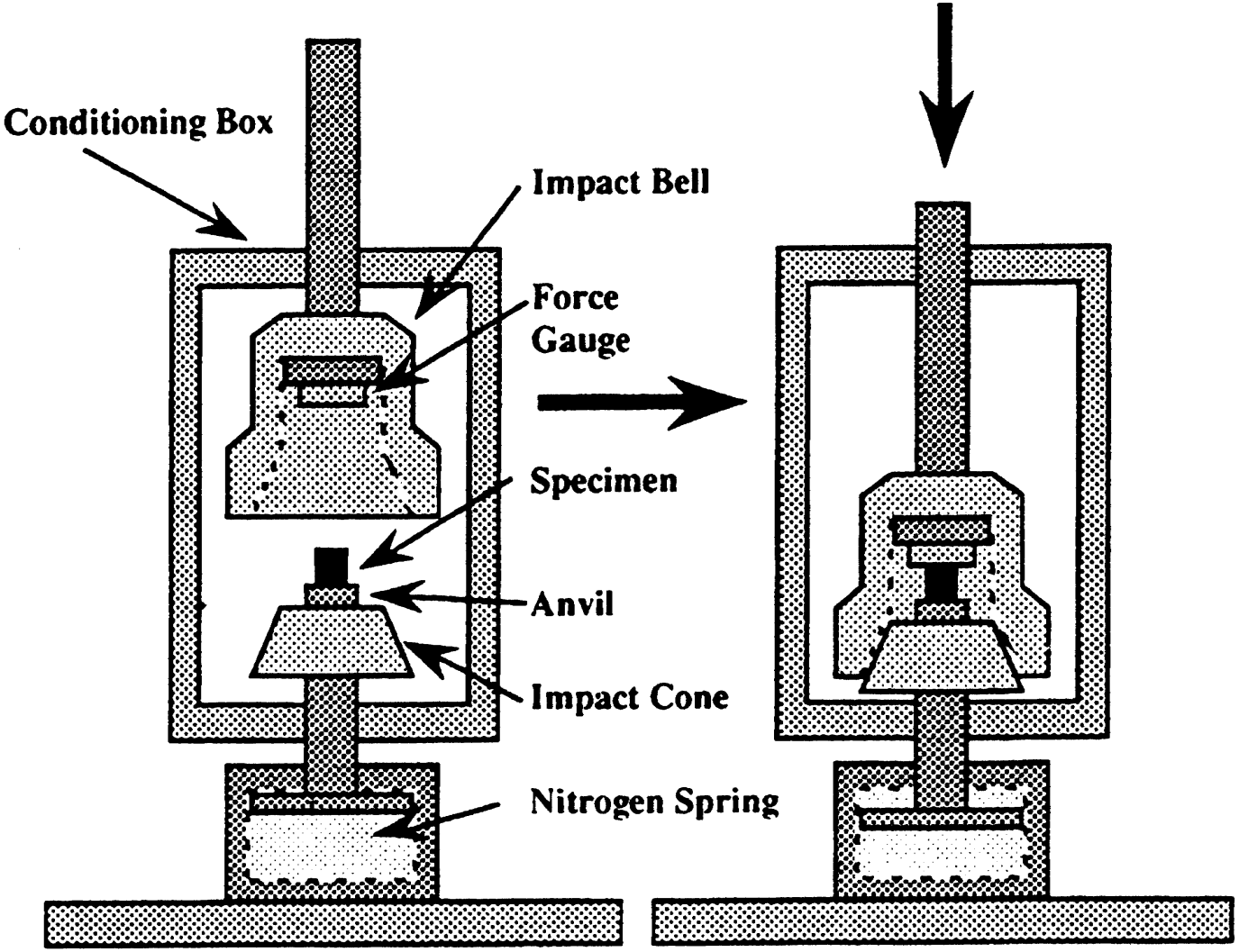


More Stringent Low Temperatures Being Considered

Conventional operating T range: ~ -20 C to 63 C

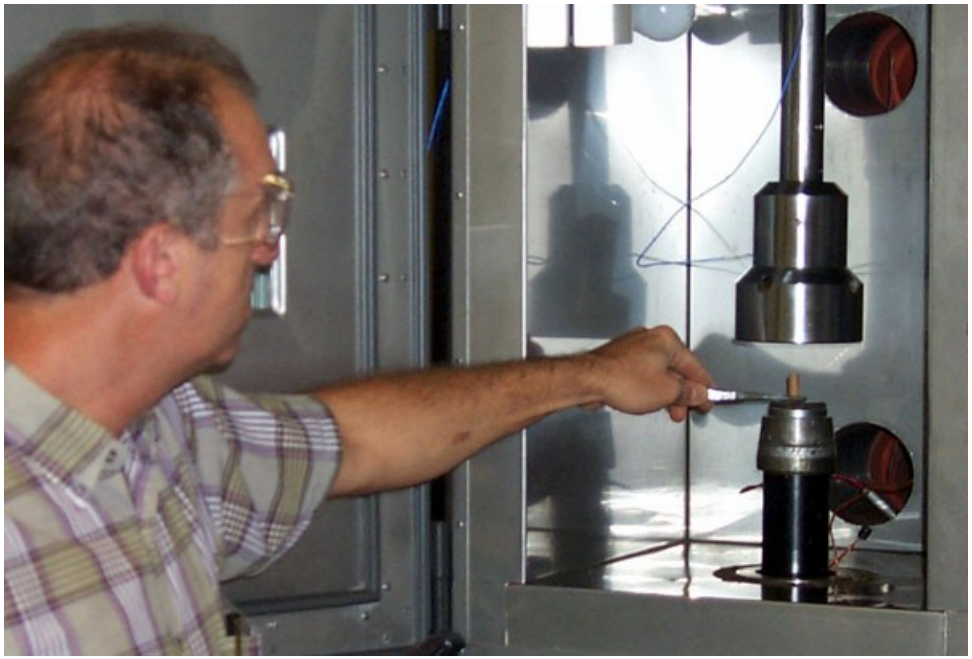
Future ranges: -32 C to 63 C

Schematic of Servohydrualic Test Apparatus



Dynamic Compression Testing Screens for Brittle Failure

Servohydraulic Test Apparatus



Specimen strain

~100 s^{-1}

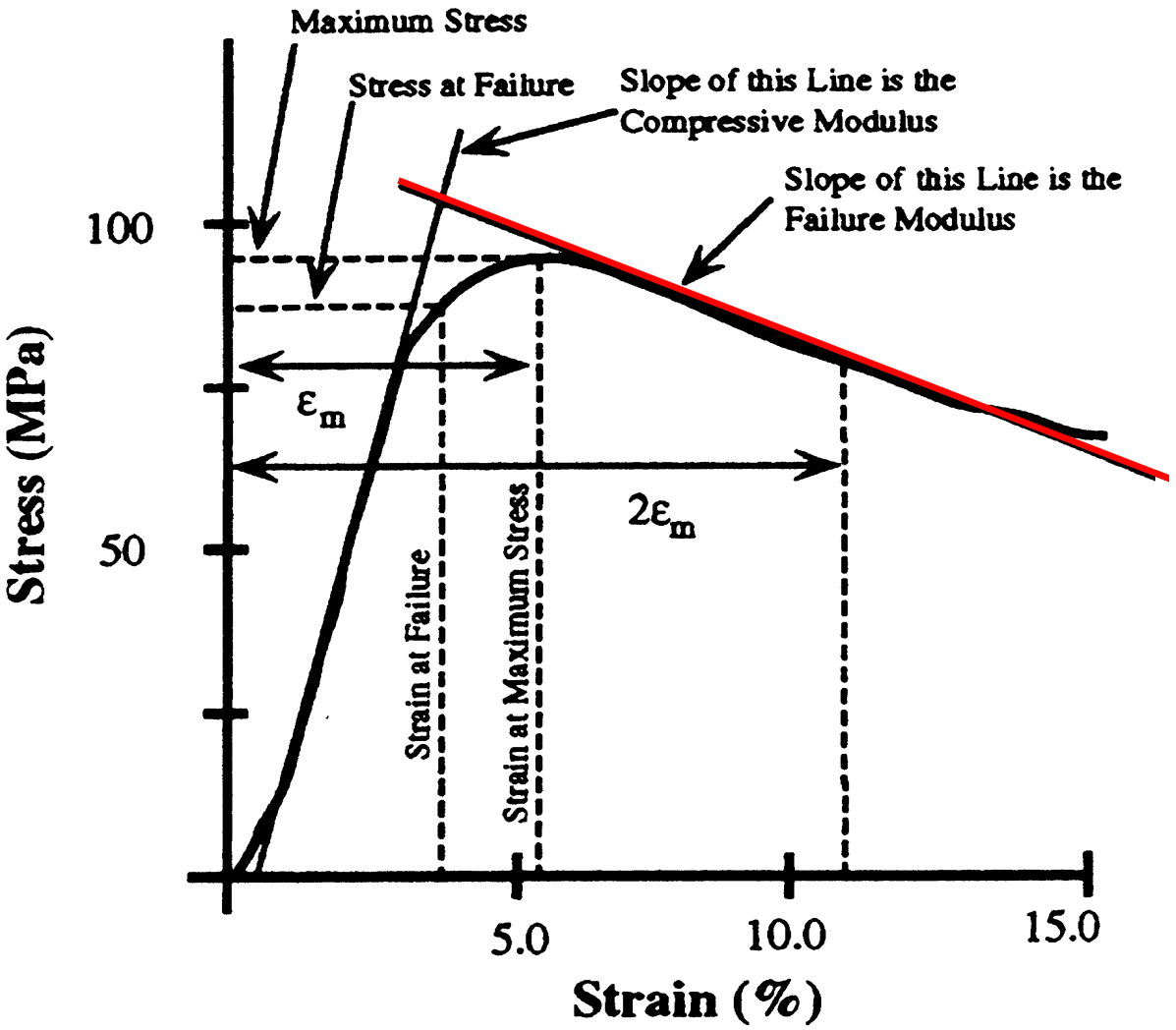
L/D ~ 1- 1.2

Diameter ~ 1 cm

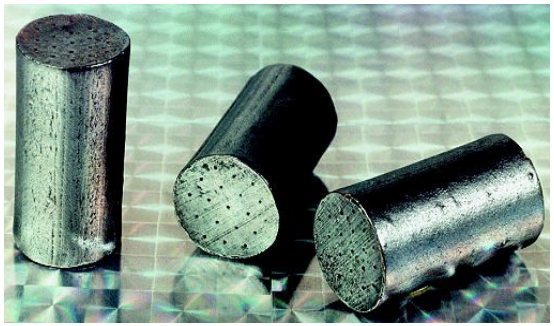
(although 0.25 inch samples have been evaluated successfully)

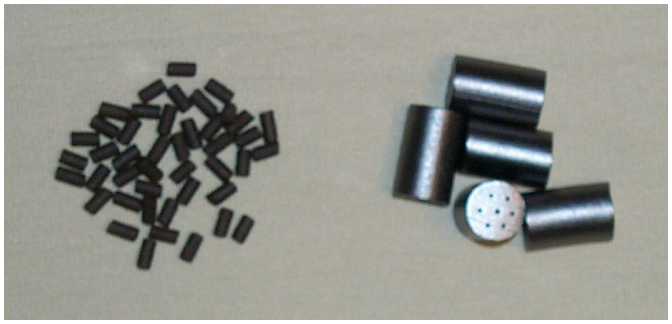
Sample is a Single Specimen

SHT Response Curve



Dimensions of Some 120-mm Cartridge Propellan



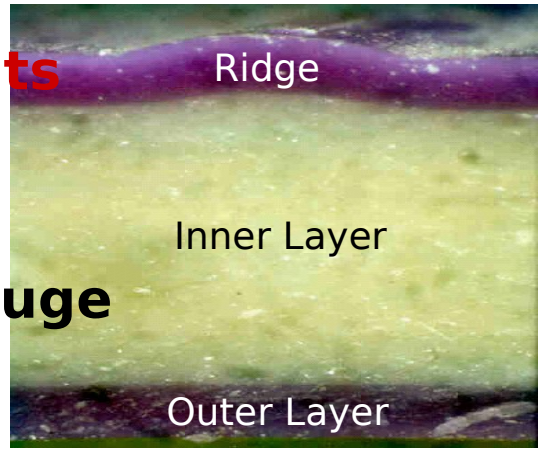


120-mm Cartridge Propellant		Length cm	Width cm	Aspect Ratio L/W
JA2	19 Perf Hexagonal	1.62	1.51	1.07
JA2	7 Perf Cylindrical	1.63		1.07
				1.6
		ndrical	1.08	

Co-layered Propellants

Width ~ 5-10x less

Aspect ratio can be huge



Solid Strand Propellant Candidates

Cylinders of L/D ~ 1

JA2 Reference

Sample A

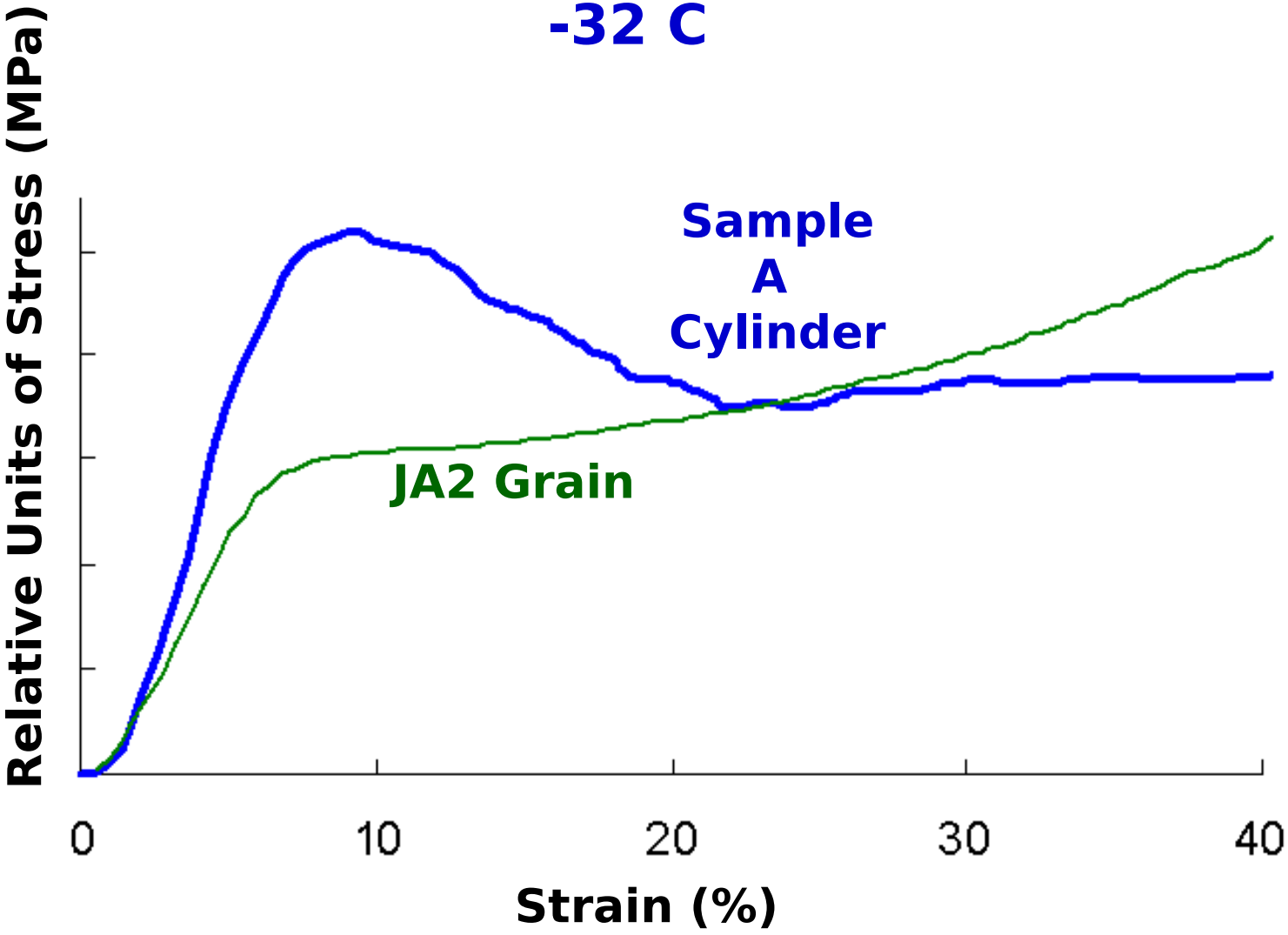
Sample B

Acceptable Fracture at -32C

The geometries of cylinders cut from strands (L/D~ 1) are amenable to SHT!

Servohydraulic Test Results

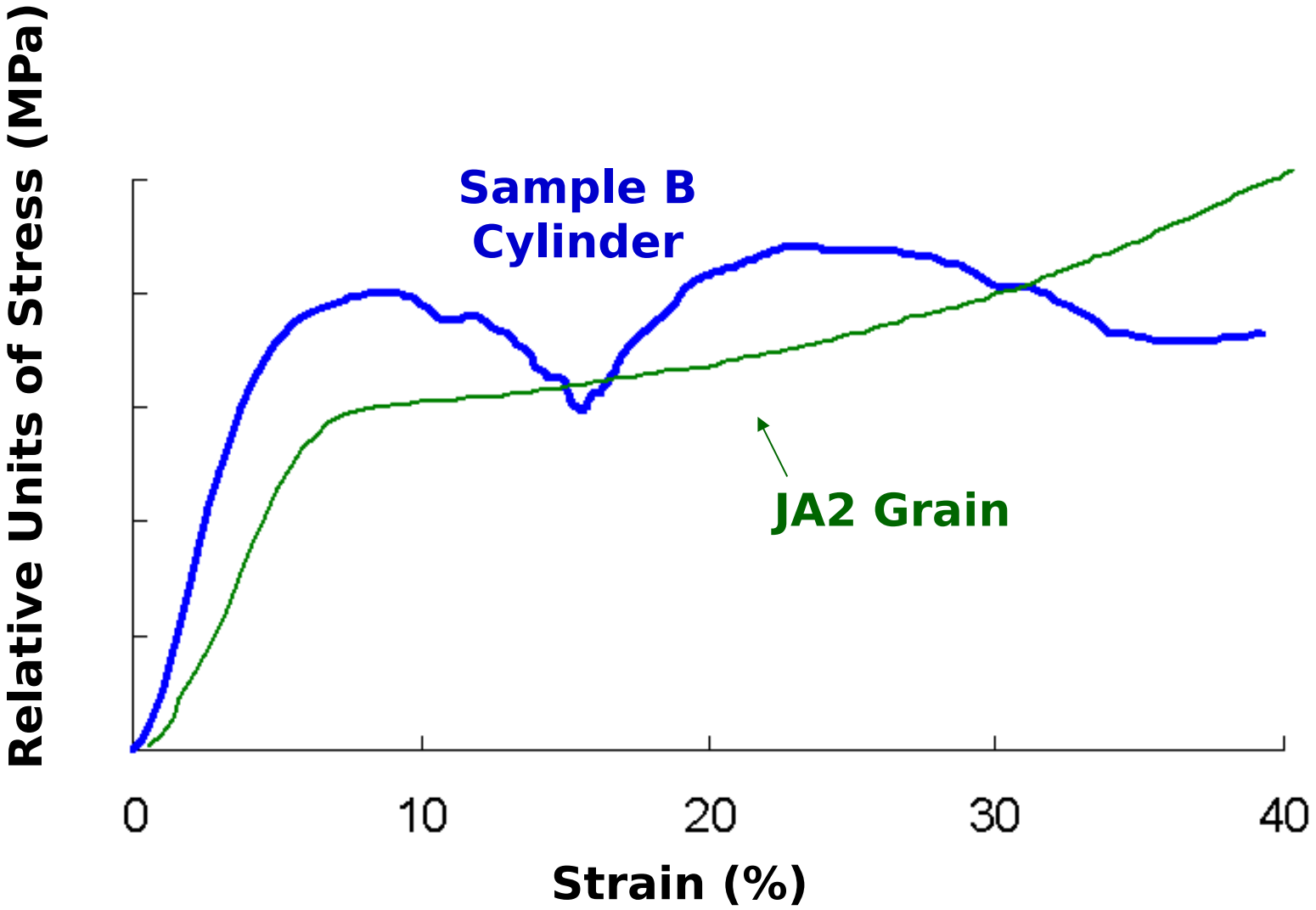
-32 C



Both of these samples maintain strength after maximum s

Servohydraulic Test Results

-32 C



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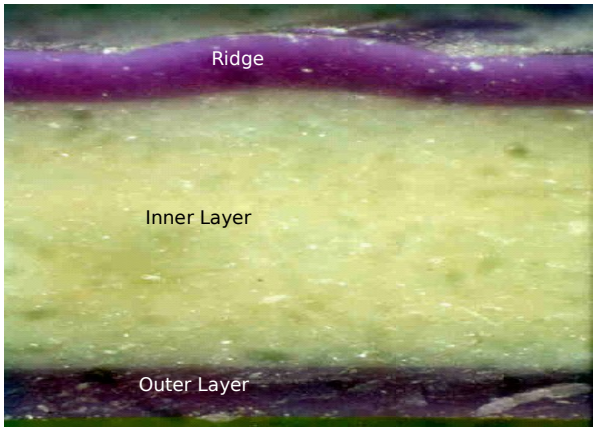
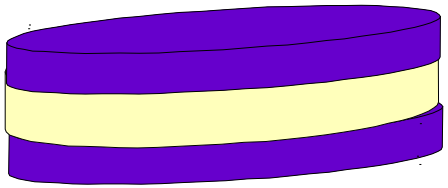
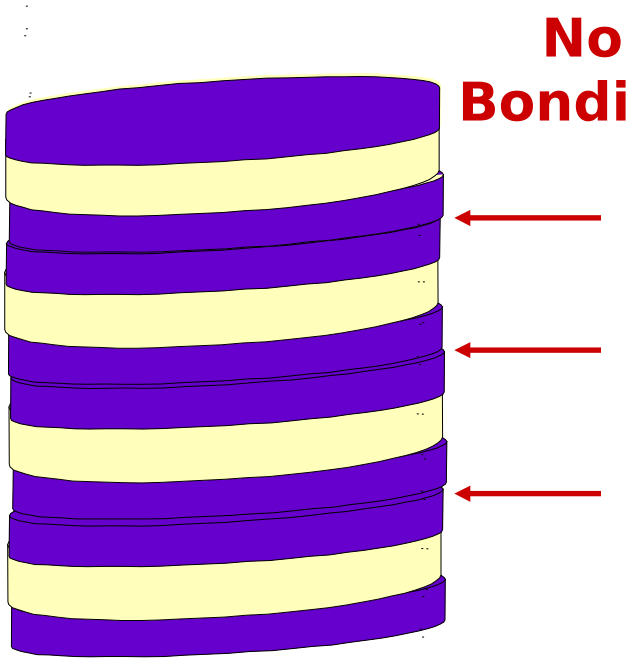
How to Test Sheet and Co-Layered Sample





Single Co-Layered Propellant Unit

Bonds Well During Processing



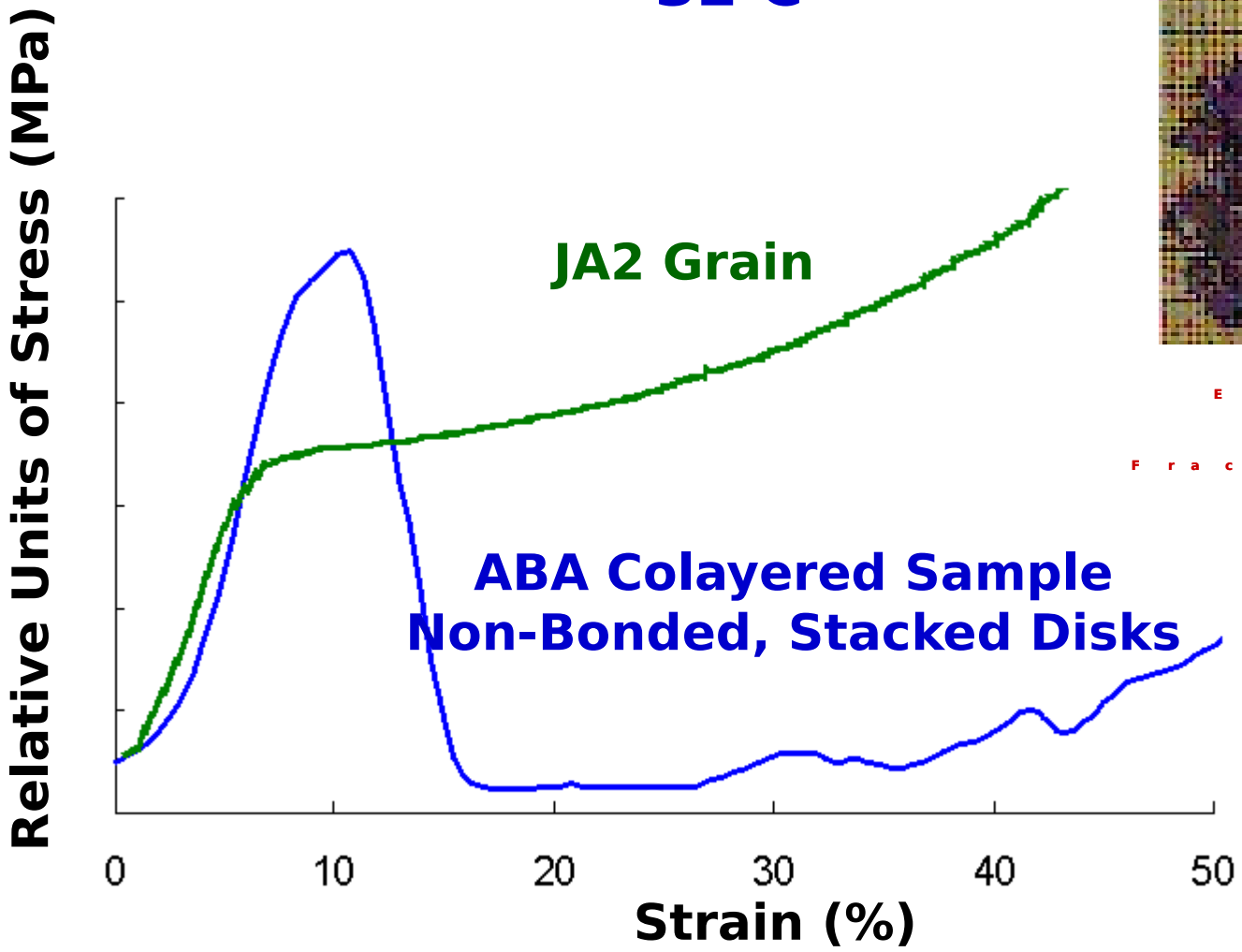
4 Colayered Units

Stacked Height ~ 1 cm

Units Not Bonded Together

Servohydraulic Test Results
-32 C

Excessive Fracture at -32 C



Stacked Samples vs Grains

What would happen

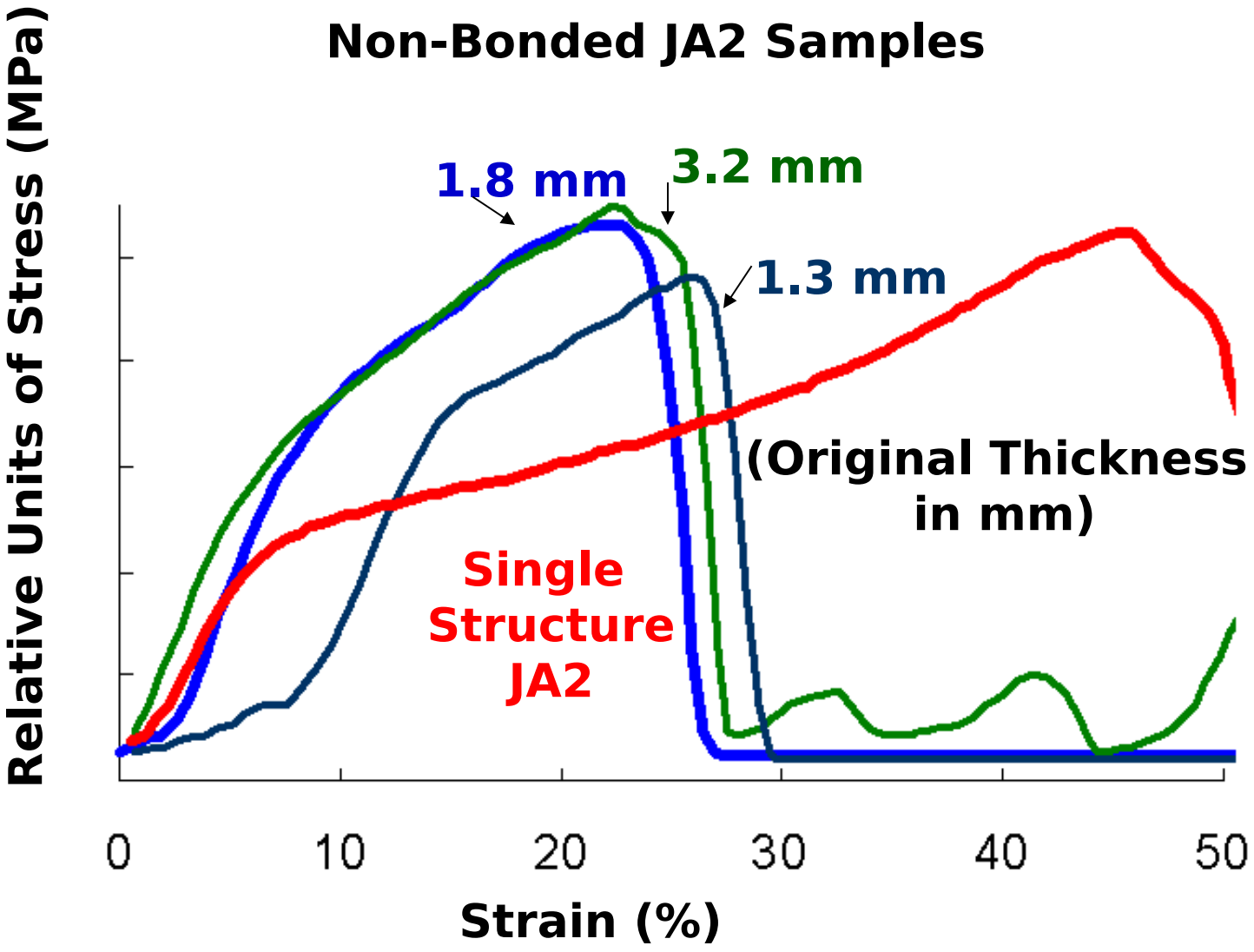
if

Loose Stacks, Cut from Sheet

JA2,

were tested in the SHT ?

Servohydraulic Test Results
Sheet JA2, -32 C



Post-SHT Archaeology

Loosely Stacked, Multi-Structure Layers

JA2

1.3 mm **1.8 mm** **3.2 mm**

Fracture at -32C

Servohydraulic Test Results

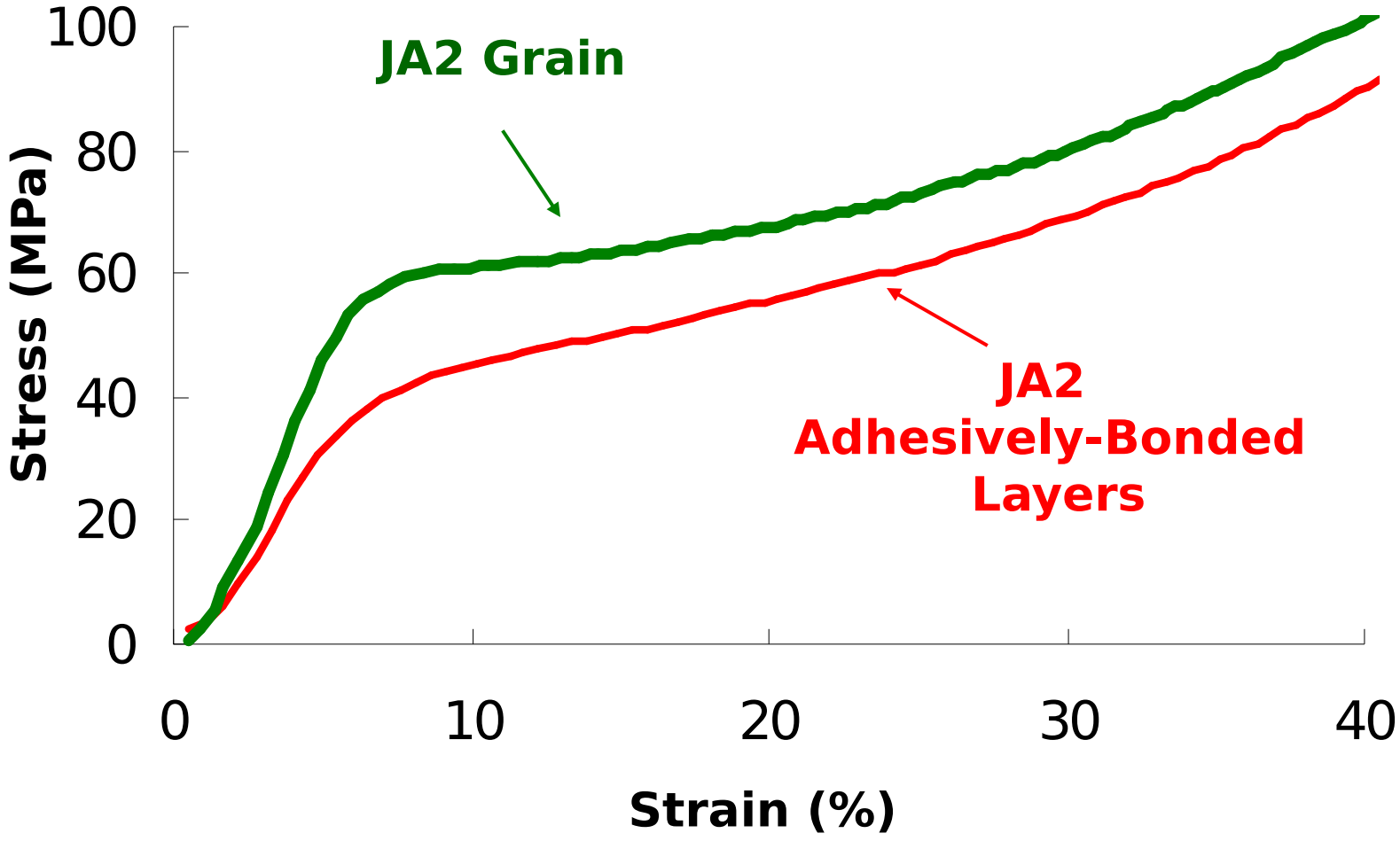
-32 C

Stacks, Cut from Sheet JA2

Securely Bonded with Minimal Adhesive

Servohydraulic Test Results

-32 C



Servohydraulic Test Results

-32 C

ETPE Samples A and B

Loose Stacks

vs

Stacks Securely Bonded with Minimal Adhesive

Non-Bonded Propellant Stacks

Before
(Sample A)

Sample A Sample B

After

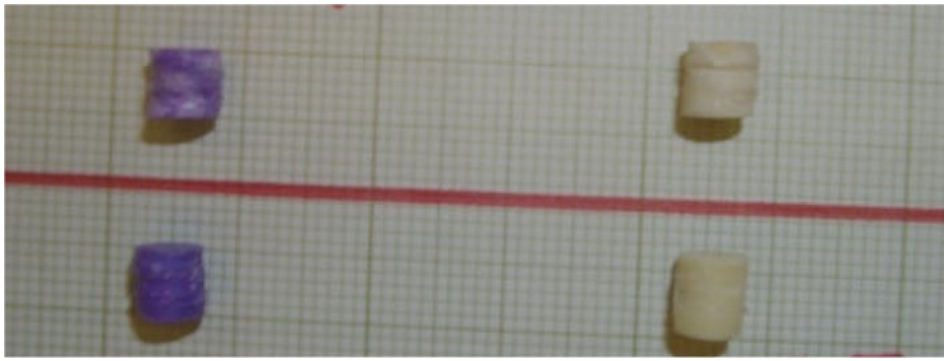
Sample A Sheet

No Adhesive Bonding

ETPE Samples Prepared for SHT Analysis -32 C

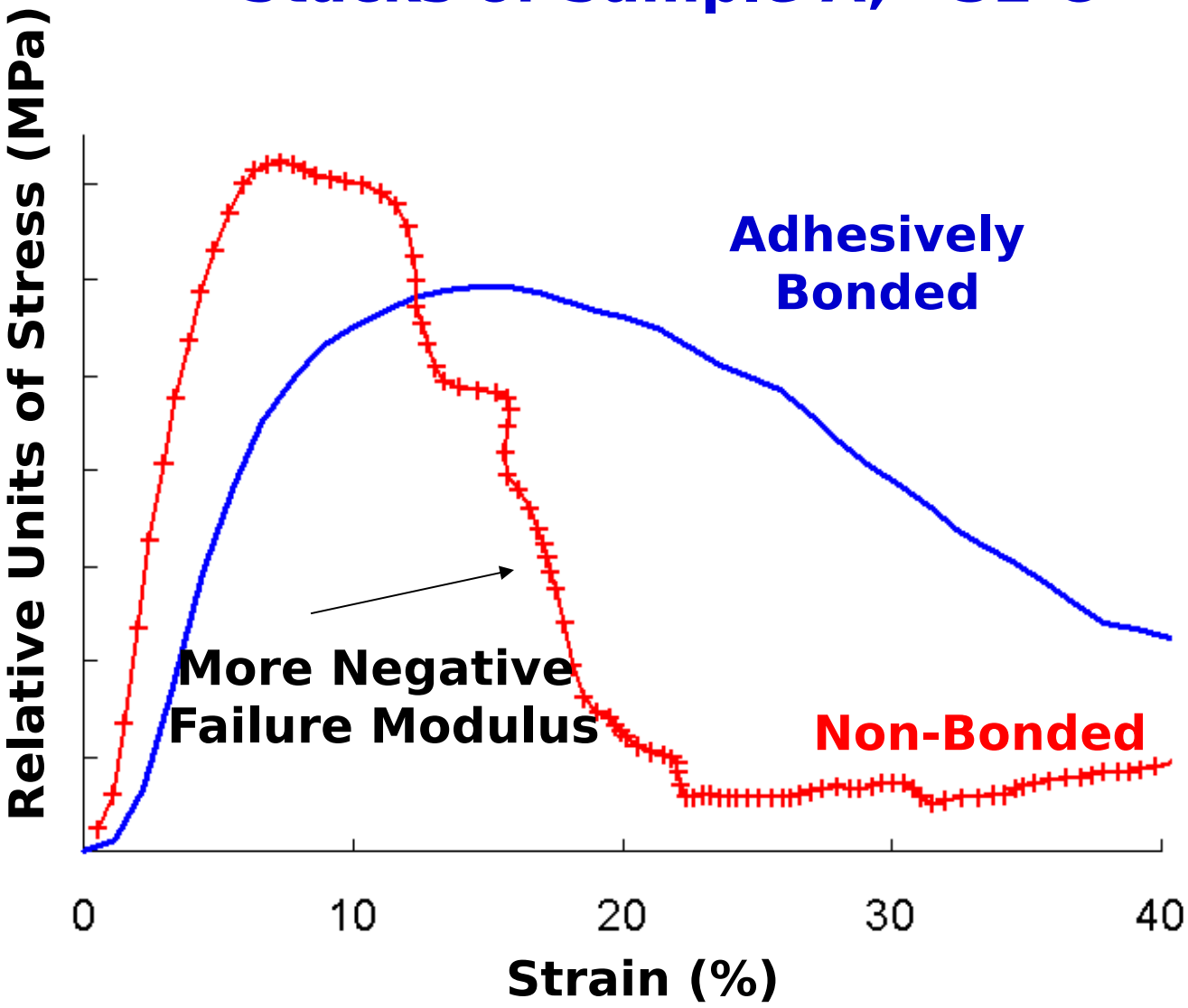
Adhesively Bonded Samples

Sample A **Sample B**

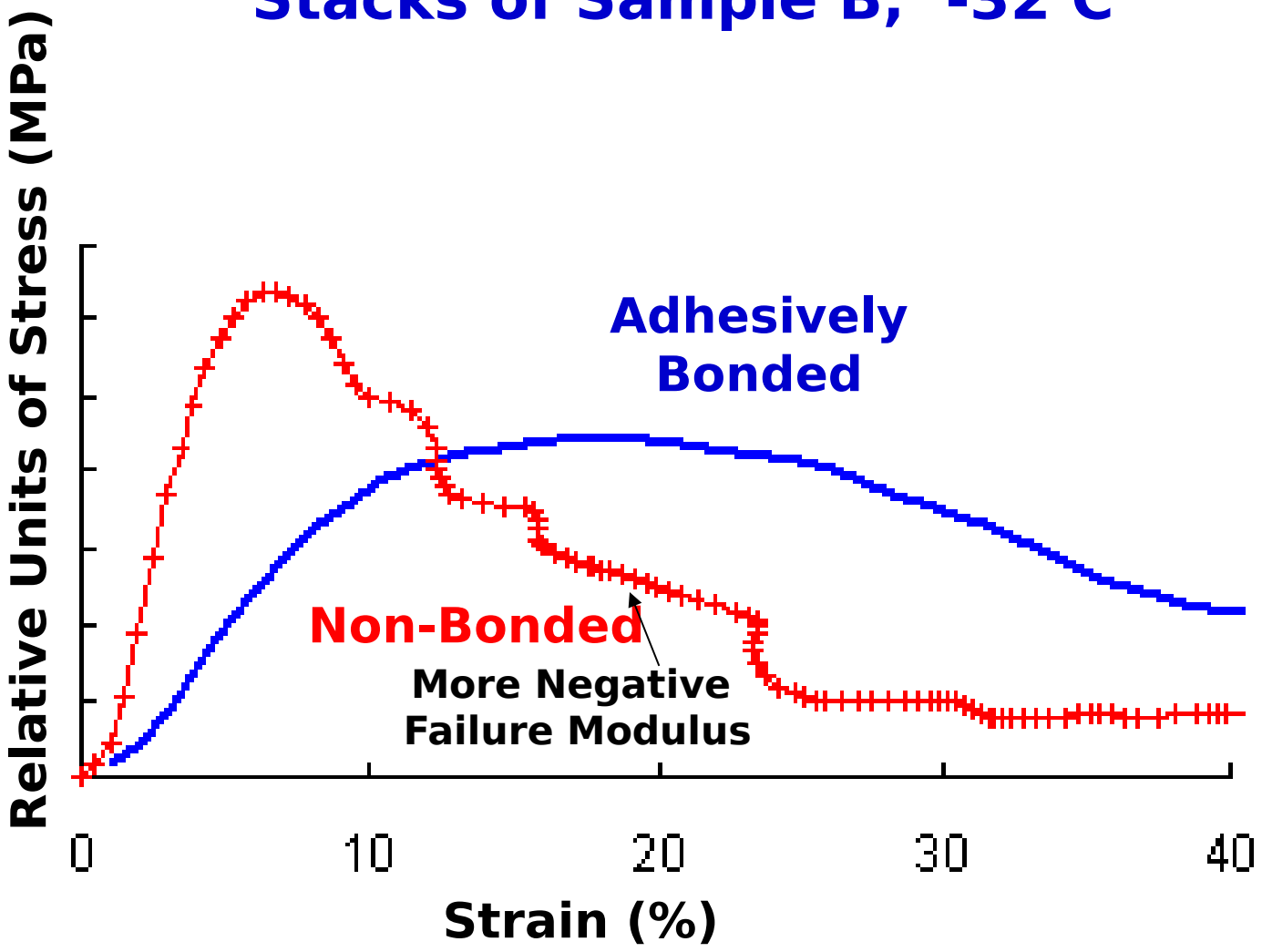


Adhesively stacked samples can barely be cut apart with a razor.

Servohydraulic Test Results
Stacks of Sample A, -32 C



Servohydraulic Test Results
Stacks of Sample B, -32 C



How do the SHT results of

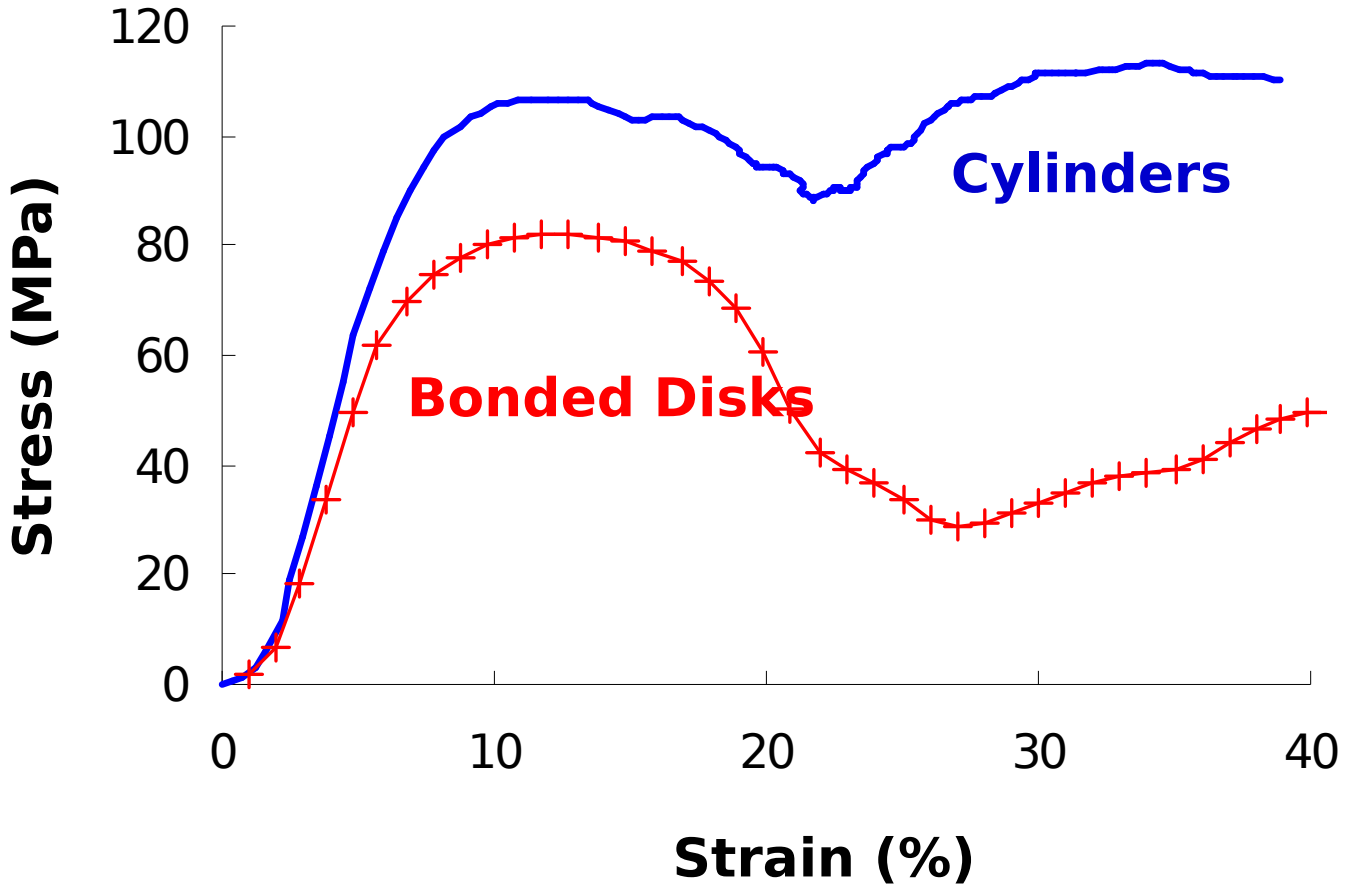
Adhesively Bonded ETPE Disks

compare with those of

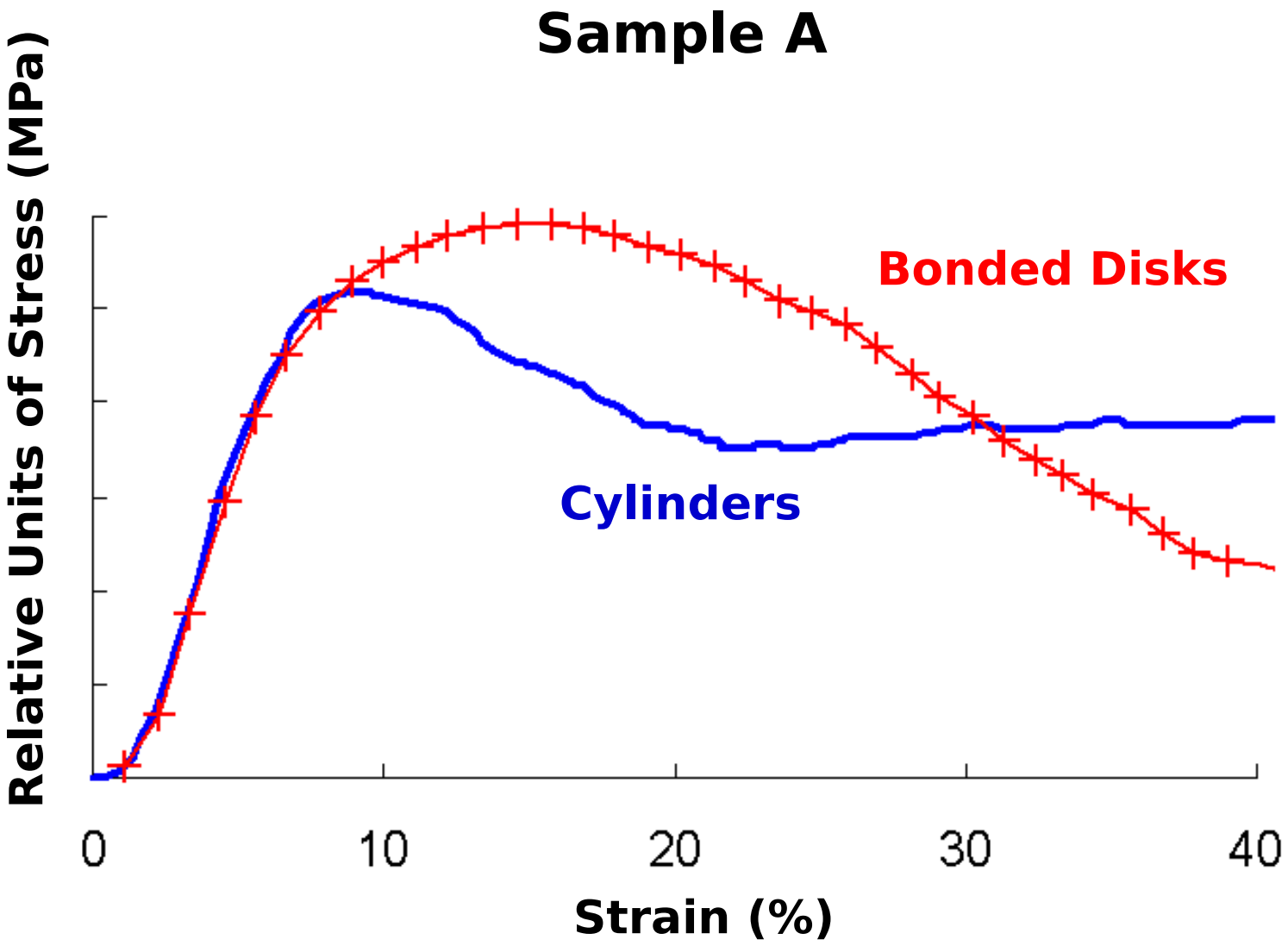
Cylinders?

Servohydraulic Test Results
-32 C

Sample B



Servohydraulic Test Results
-32 C



Summary of SHT Analysis

Stacked sheet specimens have not been validated as a measure of propellant response

Current correlations between ballistic fracture generation and mechanical response are dependant upon monolithic specimens

- **Stacked layers of JA2 exhibit significantly greater fracture generation**

Stacked layers show a response more similar to a monolithic structure when:

- **Samples that are adhesively bonded**
- **Samples that are compressed sufficiently prior to evaluation so that the individual layers do not slip, and all layers can help support a load**

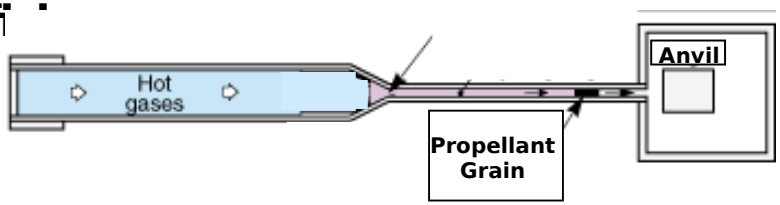
The potential exists for creating artifacts when making a

hy has SHT Screening of Granular Propellants been so Effective?

SHT Compressive Failure was correlated to propellant response under gun conditions.

Simulated Gun Conditions

Gas gun impact tester was used to fire cylindrical grains of **propellant with known burning rate** face-on at an anvil at velocities known to occur near ignition areas in large caliber guns fi

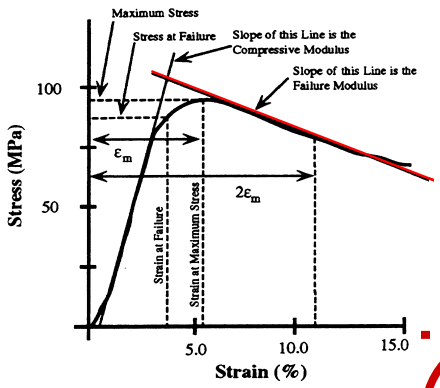


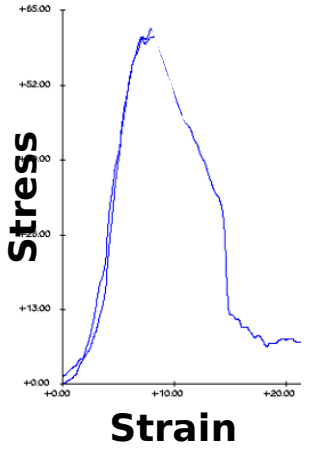
Propellant Shards Collected Quantitatively

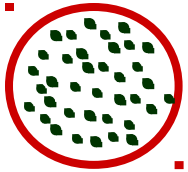
www.ditusa.com/bomb.html

Shards are fired in a closed bomb, and surface area of shard computed

SHT Analysis







Acceptable

Unacceptable

Mechanical Properties Assessment of Colayered Propellant

What is needed for colayered propellant configurations:

- To design a test to characterize the mechanical response under operational conditions

- Operational conditions, i.e. the environment to which a typical large caliber layered charge is exposed, must be determined via ballistic modeling and simulation

- Mechanical response is not solely a function of the mechanical properties of the propellant

- For all propellants, form is important

- For colayered propellants, form may be a dominant